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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The purpose of the study reported here was to establish feasibility and develop methods for testing the mass rearing and releasing of exotic introduced parasites to control vine mealybug (VMB), *Planococcus ficus* in the Coachella Valley as a basis for a stable grape pest management program.

Four species of VMB parasites from 23 locations in Central Asia, the Mediterranean, and South American were imported to California. Eighteen parasite colonies were reared, released, and screened over a period of 3 years for impact against VMB in the Coachella Valley. Sampling methods were tested to estimate numbers of VMB and parasites. Ant control was assessed for impact on parasite effectiveness against VMB. Yields from parasite release areas were compared with yields from areas receiving conventional chemical treatments to kill VMB.

Two parasite species (*Anagyrus pseudococci* and *Leptomastidea abnormis*) were found to have the greatest potential against VMB. Sixteen of 18 parasite colonies tested had greater impact against VMB than the native *A. pseudococci* from the Coachella Valley. Visual observations and yellow sticky traps were found effective and most feasible for sampling VMB and parasites respectively. Control of ants resulted in greater parasite impact against VMB. Yields were greater in areas where parasites were released compared with yields in areas treated twice with chemicals to kill VMB.

These results provide a basis for a test in a large area to assess impact of effective parasite mass releases against VMB as a part of a colonization or an augmentation program in biological control.

EXECUTIVE SUMMARY

The study reported here was in response to a new invasion by the VMB in the Coachella Valley in 1994. The new infestations were not effectively controlled by the native parasites and predators. Consequently the presence and damage by VMB have prompted continuing widespread applications of insecticides. However, the VMB's habit of congregating beneath bark and other protected spaces has resulted in many chemical applications being ineffective.

Our study is based on searching for effective exotic natural enemies from areas in other countries where VMB is not a pest and/or where effective natural enemies have co-existed with VMB over a relatively long period of time.

We have imported, reared, released and tested eighteen colonies of parasites from areas in central Asia, the Mediterranean and South America against VMB in the Coachella Valley.

We have tested and verified effective and feasible sampling methods for estimating numbers of VMB and parasites. We have tested impact of ant control on parasite effectiveness against VMB. We have compared yields from our parasite release areas with yields in areas receiving 2 chemical applications to kill VMB.

Methods for foreign exploration included a literature search and contact with collaborators in foreign countries to establish a list of potential areas and parasite species to collect for introduction and testing against VMB in California. All collections overseas were in collaboration with known established scientists in all areas of collections.

Parasite mass rearing and release techniques were modified from literature references and based on advice from foreign collaborators.

Efficacy of exotic parasites was compared among all parasite colonies being reared at UCR each year, compared to that of the native parasites from the Coachella Valley, collected prior to new parasite introductions and reared at UCR. Efficacy was assessed on parasitization of VMB manipulated in trap plants, potted and held in the Coachella Valley for 1 week for each trial. Trap plants included trials using known numbers of VMB placed on potted plants with sprouted potato tubers or on grape vines and leaves. Uncaged trap plants were placed under vine canopies in parasite release versus non release areas throughout the growing season, including periods when temperatures were cold (spring) and very hot (summer). They were used prior to releases each spring to assess overwintering potential of parasites released the previous year. Caged trap plants were also placed under vine canopies, 1 week per trial, and included parasites from distinct colonies, each enclosed in a separate isolated caged trap plant. Results from these trials provided comparative results from all parasite colonies tested under similar conditions during the test periods from spring through summer.

Sampling techniques involved comparing several methods for estimating VMB and parasite numbers. Our criteria were to find methods that were reliable, effective, and feasible in terms of permitting relatively large samples needed for further evaluations or for use by PCA's.

Ant control methods involved use of an ant bait to measure impact of ant control on parasite effectiveness against VMB. Bait was placed around some potted trap plants, described above, to measure ant control versus unbaited potted trap plants that were the untreated control.

Yield was estimated by counting number(s) of boxes with grapes at harvest time from equivalent areas under different treatments.

Results from foreign exploration over 3 years provided 23 different locations with parasites. Parasite colonies were established from 18 of those locations, serving as the basis for comparing their efficacy against VMB, among the introduced parasites and against the native parasite from Coachella. Sixteen of the exotic colonies tested had greater impact against VMB than the parasites native to Coachella.

Procedures for rearing parasites, VMB, and host plants were validated and provided us with more than 796,000 parasites for field releases and trials, predominantly several potential biotypes of *A. pseudococci*, and lessor numbers of *L. abnormis*, *C. peregrinus* and *L. dactylopii*. These procedures are available for use in a mass rearing program that can test impact from parasite mass rearing and release over a much larger area than we were able to cover with relatively limited rearing facilities and resources.

From 18 candidate parasite colonies screened in the field over 3 years, two colonies of *A. pseudococci* were the most effective. A third colony of *Leptomastidea abnormis* has potential because it attacks first and second instar of VMB whereas *pseudococci* attack fourth and fifth instars and adults.

All three colonies noted above were originally collected from grapes from hot dry areas. In field trials, they find, parasitize, survive, increase in numbers, and move in the Coachella Valley under a wide range of climatic conditions: (a) they survive hot summers and cold wet winters, they are very abundant in parasite release versus non-release areas throughout the critical grape growing season, and they have increased in numbers through a season, and over several years; (b) in all trials they have demonstrated significantly greater impact against VMB in comparison trials using the standard as the native *A. pseudococci* collected from the Coachella Valley prior to our release of exotic parasites.

We have tested and validated sampling plans necessary to estimate VMB and parasite numbers. These sampling plans can be used to assess mass rearing and release programs to critically assess a potential for colonization or augmentation programs from a mass release program involving larger numbers of parasites released over a greater area than we were able to test with limited facilities and resources.

The preliminary small scale ant control trials provided data that support our belief that parasites will more effectively control VMB in the absence of ants.

Preliminary yield data have provided a basis for demonstrating to growers the feasibility for releasing parasites to control VMB without risking economic loss. Additional trials with ant control via use of baits should enhance the effectiveness of parasite releases.

Results to date are promising and provide evidence that there is a good potential for avoiding the mass rearing and release problems that have plagued some other mealybug parasite release programs such as with the pink hibiscus mealybug in the Caribbean (Meyerdirk et 1998), and the cassava mealybug in Africa (report by Hans Herren posted on the Internet). .

A. INTRODUCTION

This project was aimed at providing the basis for a long-term, stable grape pest management program in the Coachella Valley. Management and coordination of the program was proposed through establishment of an IPM Innovator Program in which growers will be an integral part of a decision-management system served by technical and non-technical advisors. Technical Advisors will include University Researchers and extension farm advisors, California Department of Food &Agriculture personnel, Riverside County personnel, and (private) pest control advisors.

We had four primary objectives: 1) establishment of an IPM Innovator Program using guidelines provided by the Department of Pesticide Regulation, California Environmental Protection Agency, 2) to screen and evaluate the impact of native biological control agents (screen native natural enemies and assess their effectiveness in the field, 3) to import, rear, and release beneficial insects in selected sites and determine the status of colonization success the following year (i.e. 1996, 1997), 4) to obtain information on ant species that tend the vine mealybug, *Planococcus ficus*, populations and to test control methods to eliminate or reduce ant numbers without disturbing natural enemy populations (Nixon 1951, Shorey et al 1992).

In the Coachella Valley, and other desert growing regions of Riverside Co., a previously unencountered mealybug pest was discovered in June 1, 1994 at Mecca from “Flame” table grapes (Gill 1994). This new pest represents a serious economic threat for California table grape cultivations, not only because of direct feeding and production of copious quantities of honeydew (upon which mold develops), but also because it is a vector of two serious diseases: the grapevine corky bark virus and grapevine leafroll disease. Although the preferred hosts of the vine mealybug (VMB) are apparently grape and fig, the genus has also been recorded as a pest of apple, avocado, banana, citrus, date palm, mango, pomegranate, and ornamentals (Cox, 1986). Potential thus exists for this pest to move to other crops and cause even more extensive economic damage. In 1994, the total losses at one heavily infested vineyard were estimated to have been $180,000 (Charles Schmidt, personal communication). At another vineyard, the damage was estimated to have been over $300,000. A third farm manager reported that he was losing 20% of his production and that this was costing him $1,800/acre. In 1995, Eldon Reeves estimates that out of 15,000 acres in the Coachella Valley, more than 13,000 are infested. Heavy losses on several farms were reported in 1996.

The VMB infestations are widespread, resulting in greatly increased and widespread applications of insecticides with concurrent increases in costs and high risk of inducing secondary pest and resurgence problems. Several vineyards have been abandoned because of infestations (Charles Schmidt, personal communication). VMB infestations were confirmed in 1998 in Kern and Fresno counties. This pest now threatens over 600,000 acres in the San Joaquin Valley. Other mealybug infestations are also presenting increasingly serious problems in the Santa Barbara and San Joaquin areas (K. Daane, personal communication).

The presence of VMB in orchards and vineyards and the resulting damage due to sooty mold contamination of grape bunches and weakening of vines due to the direct feeding of the pest has led in many cases to the use of chemical control measures. However, because of the mealybug’s habit of congregating beneath bark and in other protected places, chemical controls are difficult or ineffective (Berlinger, 1977). Use of chemicals also upsets the existing natural balance, causing secondary pest outbreaks in grapes and other adjacent crops such as alfalfa, citrus, dates and ornamentals. In many crops, chemical applications rapidly result in resistant pest populations (especially spider mites) for which there are no control measures.

In collaborative surveys in 1994-98, with CDFA and Riverside Country personnel, extremely low levels of native natural enemies of mealybugs were found. This indicates a lack of effectiveness by natural enemies presently existing in the Coachella Valley.

The vine mealybug exists in several other countries (Berlinger 1977; Myartseva 1984, Cox 1986) where populations are normally under effective biological control (Mysartseva and Nyazov 1986). Especially promising collecting sites are Turkmenistan, Israel, Ukraine (Crimea-where the vine mealybug was originally discovered), France and Spain. Natural enemies of this mealybug are known to occur in all of these countries. We have personally contacted collaborators in each of these countries who are actively involved in research programs and who have assisted us in locating and collecting mealybug enemies. The following is a partial list of some of the parasitoids that are known to attack *P. ficus* elsewhere in the world: *Leptomastix dactylopii* Howard, *Coccidoxenoids peregrinus* (Timberlake), *Anagyrus pseudococci* (Girault), *Leptomastidea abnormis* (Girault) and *Clausenia josefi* D. Rosen (Rosen and Rossler 1966. Berlinger 1973a, 1973b 1977; Myartseva 1984; Triapitzyn 1989).

In 1995, 1996, and 1997 we collected parasites of vine mealybugs in Turkmenistan, Spain Israel, and Argentina. From these collections, *A. pseudococci, L. abnormis L. dactylopii* and *C. peregrinus* were recovered, imported, reared, released and evaluated against VMB in the Coachella Valley.

In collaboration with Joe Ball and Kris Godfrey (CDFA) and E. Reeves (Riv. Co. Ag. Comm.), we surveyed to establish background data on native natural enemies present in the Coachella Valley. From collections over 4 years we found extremely low levels of parasitization, <u>not</u> effective against the level of mealybugs found.

B. MATERIALS AND METHODS

The phases of the project were (a) foreign exploration and importation of exotic parasite species and potential biotypes having a potential to significantly impact against VMB on grapes in the Coachella Valley; (b) rearing and release of selected parasite species/biotypes; (c) recovery and field evaluation in the Coachella Valley of released parasites via (i) caged trap plants with VMB and selected VMB parasites, (ii) uncaged trap plants with VMB in open fields in parasite release versus non-release areas, (iii) comparison of sampling techniques for recovery of parasites and for estimating VMB numbers and damage, and (iv) collection of yield data to compare yield in parasite release areas with yield in areas treated under a conventional grower insecticide program.

Foreign exploration was selected in countries from hot, dry areas where VMB was known to be under various degrees of biological control. Travel to every location was in close collaboration with local entomologists who accompanied D. González to all field sites except Turkmenistan where collaborators collected and mailed parasites to us. Parasites were shipped via airfreight and received in the quarantine facility at the University of California, Riverside. All foreign exploration costs were paid from funds from the University of California and/or from the California Table Grape Commission.

All rearing was at the Insectary, University of California, Riverside. Parasites were reared in separate rooms to avoid contamination. Releases were made at weekly intervals during 3 time periods over the season, corresponding to: (a) early, (b) middle, and (c) late-season mealybug infestations. Releases at 3 time periods were programmed to permit assessment of parasite performance under different temperatures: under (a) relatively cool (b) very hot, and (c) moderately hot conditions. The 3 time periods also corresponded to different mealybug numbers: (a) lowest, (b) highest, and (c) declining.

The 3 time periods also corresponded with exposure of mealybugs to parasites under different conditions: (a) relatively low numbers of mealybugs, difficult to find, mostly under bark; (b) high numbers of mealybugs, many on fruit clusters and/or leaves; and (c) moderate numbers of mealybugs mostly under bark but some on canes and leaves.

We had a minimum of 4 replications for each parasite species (or potential biotype) released at each of 3 densities. Pre-release data was collected and then again 1 week following each release. All plant trap samples were collected and transferred to the laboratory where they were stored and counted after allowing time for development and emergence of parasites into cages. Estimates of ant numbers and species were taken with visual samples.

Assessment of parasite performance was based on 3 criteria: (1) parasites recovered from VMB on uncaged trap potted plants or from yellow sticky traps left for 1 week in release vs. non release areas, (2) parasites recovered from caged trap potted plants left under vine canopies for 1 week and then returned to the laboratory where they were held for emergence, and (3) yield data from parasite release areas versus areas under grower conventional insecticide treatments for VMB and ants.

Potted trap plans consisted of either sprouted potato tubers or grape vines with foliage, infested with VMB and placed in the field for 1 week either (a) uncaged and exposed to parasites in that environment, or (b) caged with white nylon organdy enclosing each cage and 5 parasites of a known parasite species or biotype. Uncaged trap plants were left in the field under foliage canopy and surrounded by either Maxforce for ant control or no treatment for ant control.

Yield was recorded at harvest time from equivalent areas (vines per designated distance) from designated treatment areas.

Sampling for VMB presented a very difficult problem because VMB are concealed under bark until the fruit begins to set. They then infest the fruit, but disappear under bark again after harvest. We tested several methods for sampling VMB numbers and found time-limited visual samples to be as reliable as several other methods, but much more feasible because of less time required. This permits a much greater number of samples to be taken in comparable time periods. The habits of VMB prior to fruit set require a large number of samples.

Similarly, sampling for recovery of parasites from parasite release versus no release areas presented a difficult problem because of the need to take a large number of samples under limited time constraints. We tested several sampling methods and found yellow sticky traps as reliable as several other methods we compared them with. Yellow sticky traps are more feasible than the other methods tested because they require shorter processing time, allowing a far greater number of samples to be collected in comparable time periods.

C. RESULTS

Results are presented in order of the sequence in which studies were carried out, over a 3-year period, and each year: (a) foreign exploration/importation of exotic parasites with a potential for attacking vine mealybug, (b) rearing of selected species, (c) field release of species and (d) field evaluation and recovery of parasites released, from (i) caged trap plants and (ii) in open field from uncaged trap plants in parasite release versus non-release areas.

Importation of vine mealybug parasites is summarized in Table 1. A total of 4 parasite species from 23 different locations in 4 countries were collected and imported in 1995-97. Collections were from 23 different locations, differing in climate, habitat, and crop. Localities differing in 1 or more environmental characteristics were purposely selected to promote a potential for acquiring parasites of the same species with different behavioral characteristics, i.e. differences in their impact against vine mealybugs (= potential biotypes).

Anagyrus pseudococci were the overwhelming parasites collected in all areas. This is a strong indication that in areas sampled this parasite is by far the most abundant. As confirmed by evaluation trails (noted below) there were marked differences in impact against vine mealybug from the more than 10 potential biotypes of *Anagyrus* collected from 4 countries over a 3 year period.

Parasite releases were conducted in open fields and results evaluated by placing vine mealybugs on trap crops in parasite release areas and in adjacent non-release area. More than 400,000 parasites were released on 4 farms in 1996 over a period of 8 months. Parasites released were predominantly from 10 potential biotypes of *A.pseudococci*. Lessor numbers were released of *L. abnormis* and *C. peregrinus.* In 1997 more than 230,000 parasites were released predominantly from 6 potential biotypes of *A. pseudococci*, with lessor numbers of *L. abnormis* and *C. peregrinus.* In 1998 more than 166,000 VMB parasites were released. Most of the parasites were from 3 potential biotypes of *A. pseudococci*. Lessor numbers of *L. abnormis* were released.

Results of recovery of parasitized VMB from uncaged trap plants in parasite release versus non-release areas is shown in Tables 2 - 4 and in Figures 3 - 5. There were significantly greater numbers of parasites recovered from parasite release versus non-release areas at all times of the year including periods when temperatures varied from very cool to extremely hot. Higher numbers of parasites from release (the previous year) versus non-release areas were also collected in early spring before parasite releases were made. This provided evidence that released parasites survive the winters as well as the extremely hot summers. The evidence also indicated significantly that introduced exotic parasites were more effective that the resident native parasites in the non-release areas.

In 1998 we compared uncaged potted grape vines versus uncaged potted potato sprouts to estimate effectiveness of recovery on these 2 host plants in release versus non-release areas. Trends in results were similar, although somewhat higher numbers of parasites were recovered from VMB on grapes than on potato plants. However, processing in the laboratory of plant material to recover parasitized VMB required about 10 times more time for grape than for potato plants. The extraordinary time required to process grape plants for this procedure makes this method completely unfeasible.

Evaluation of the potential biotype differences among *A. pseudococci* and between the 4 species was conducted in the Coachella Valley in 1996-98. The gradual sequential reduction in potential biotypes and species assessed reflected results obtained each year. Results are shown in figures 1, 2, 6 and 7. Each year we selected the top 2 potential biotypes of *A. pseudococci* and compared those with the native *pseudococci* and with new parasite introductions. *L. abnormis* was assessed all 3 years because it is the only parasite we have found that effectively attacks only the young (1st and 2nd instars) VMB. *A.pseudococci* attack 3rd and 4th instars and adults. *L. dactylopii* and *C. peregrinus* were eliminated because their performance was notably less than that of the *A. pseudococci* native to Coachella (before introductions). In all 3 years all of the *A. pseudococci* potential biotypes (except 2) and all trials of *L. abnormis* provided evidence of significantly greater impact against VMB than that provided by the test standard in all trials, parasites originally native in the Coachella Valley.

In 1997-98 preliminary trials were assessed for impact of ant control on parasite effectiveness (Table 5). The material tested was Maxforce, an ant bait approved for use in urban areas. Early season results were encouraging but late season results suggest that we need to test larger areas to promote maximum effectiveness in time and place. Ant species collected were identified as *Formica perphinosa* and California Fire ants (*Solenopis* species).

Several sampling techniques were tested to estimate relative numbers of VMB and VMB damage, and relative numbers and movement of parasites. Visual observations for relative estimates of VMB numbers and VMB damage were the most reliable, cost effective and feasible from several methods tested. Yellow Sticky-cards were the most reliable, cost effective and feasible for relative estimates of parasite numbers and movement from several methods tested (Table 6).

Higher yields were obtained from chemically untreated areas including parasite release and completely untreated, compared with yields from surrounding vinyards treated 2 times with Lannate to kill VMB (Table 7). These results demonstrate feasibility for providing selective field-insectary areas where parasites may be mass-released for spread to other areas as a basis for colonization and/or augmentation programs.

D. DISCUSSION

Foreign exploration from mealybugs in hot, dry areas provided us with over 23 parasite colonies (species and/or biotypes) to assess for potential to control VMB on grapes in the Coachella Valley. We assessed 18 of those 23 colonies including 4 of 5 parasite species reported to attack VMB. The fifth species reported from Israel was never found over 3 years of collections for this species.

Procedures for rearing parasites, VMB, and host plants were validated and provided us with more than 796,000 parasites for field releases and trials, predominantly several potential biotypes of *A. pseudococci*, and lessor numbers of *L. abnormis*, *C. peregrinus* and *L. dactylopii*. These procedures are available for use in a mass rearing program that can test impact from parasite mass rearing and release over a much larger area than we were able to cover with relatively limited rearing facilities and resources.

From 18 candidate parasite colonies screened in the field over 3 years, two colonies of *A. pseudococci* were the most effective. A third colony of *Leptomastidea abnormis* has potential because it attacks first and second instar of VMB whereas *pseudococci* attack fourth and fifth instars and adults.

All three colonies noted above were originally collected from grapes from hot dry areas. In field trials, they find, parasitize survive, and increase in numbers and move in the Coachella Valley under a wide range of climatic conditions: (a) they survive hot summers and cold wet winters, they are very abundant in parasite release versus non-release areas throughout the critical grape growing season, and they have increased in numbers through a season, and over several years; (b) in all trials they have demonstrated significantly greater impact against VMB in comparison trials using the standard as the native *A. pseudococci* collected from the Coachella Valley prior to our release of exotic parasites.

We have tested and validated sampling plans necessary to estimate VMB and parasite numbers. These sampling plans can be used to assess mass rearing and release programs to critically assess a potential for colonization or augmentation programs from a mass release program involving larger numbers of parasites released over a greater area than we were able to test with limited facilities and resources.

The preliminary small scale ant control trials provided data that support our belief that parasites will more effectively control VMB in the absence of ants.

Preliminary yield data have provided a basis for demonstrating to growers the feasibility for releasing parasites to control VMB without risking economic loss. Additional trials with ant control via use of baits should enhance the effectiveness of parasite releases.

Our results to date are promising and provide evidence that we have a potential for solving the VMB problem as occurred with mass rearing and release of exotic parasites with the pink hibiscus mealybug (Meyerdirk et al 1998) in the Caribbean, and with the cassava mealybug in Africa (report by Hans Herren posted on the Internet).

E. SUMMARY AND CONCLUSION

The results obtained provide the essential baseline information needed to establish a large area parasite mass rearing and release program to test the feasibility of colonization or augmentation strategies for resolving the VMB problem on grapes.

We followed a strategy frequently used in testing for host plant resistance: (a) collection and introduction of new germ plasm; (b) small scale testing to select leading candidates; (c) development of methods for testing leading candidates in large plots. Presently, we are at the stage where we have available, tested, viable parasites, and methodology and potential for success, to test their mass rearing and release over a large area.

We have involved growers, extension personnel, private pest control advisors (PCA's), commercial insectary personnel, and a research specialist in ant control. All of these components will be used in further assessment of our findings in a large-scale parasite mass rearing and release program to assess colonization or augmentation strategies to resolve the VMB problem with biological control.

We believe the following represent our major results in this study:

- A commitment of funding and land to continue this program supported by Coachella Valley Grape Growers.

- Selection of 2 successful parasite species as candidates for mass rearing and release

- Candidate parasites effective under a wide range of condition.
- Significantly more impact against VMB than that provided by native Coachella parasite.
- Potential for greater effectiveness with significant ant control.
- Practical, feasible sampling plans available for future use in implementation programs.
- Feasibility demonstrated that parasite mass release program is as or more effective in yields as conventional insecticide program
- Effective biological control program will provide viable alternative to using chemicals to growers.
- Reduced reliance on chemicals that may be eliminated as a result of passage of the Food Quality Protection Act (FQPA)
- Reduced chemical residues in ground water.

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Table 1. Importation of vine mealybug parasites. 1995-97

Year Collected	Parasite Species	Country Origin	Crop Origin
1995	Anagyrus pseudococci	**ISRAEL**	
		Arugot*	Grapes
		Givat Ada*	Grapes
		Kibbutz Yaatir	Grapes
		Kibbutz Givat	Citrus
		Ysrael Valley	Citrus
		Kfar Tabor	Figs
		SPAIN	
		Algeciras	Citrus
		San Martin	Citrus
		TURKMENISTAN	
		Ashgabat	Grapes
	Coccidoxenoides peregrinus	**ISRAEL**	
		Bet She'an	Grapes & Citrus & Pomegranite
	Leptomastix dactylopii	**ISRAEL**	Commercial Insectary (Citrus)
	Leptomastidea abnormis	**ISRAEL**	
		Bet She'an	Citrus & Pomegranite
1996	*Anagyrus pseudococci*	**SPAIN**	
		Cabezuelas*	Grapes
		Estacion de Blanca*	Grapes
		Monforte	Grapes
		Ramblillas	Grapes
		San Juan	Grapes
		Cabezuelas	Figs
		Jerez	Citrus
		San Pablo	Citrus
1997	*Anagyrus pseudococci*	**ARGENTINA**	
		Albardon, San Blas	Grapes
		Catamarca, Tres Puentes	Grapes
	Leptomastidea abnormis	Chilecito, Villas Mazón	Grapes

* Most effective in trials over a minimum of 2 years, among parasites from grapes from areas with very high summer temperatures

Table 2. Total Parasites Recovered from Open Field Trials. 1996

Sunworld 1A

Area	Females	Males	Total Parasite
Release	100	44	144
Non Release	0	0	0

Table 3. **Post parasite release samples: Parasites recovered from potato trap plants infested with VMB and exposed in field for one week * 1998**

Field	Recovery Date	RELEASE AREA			NON RELEASE AREA		
		Anagyrus	**Leptomastidea**		**Anagyrus**	**Leptomastidea**	
ORGANIC	May, 28	38	17		43	7	
	June, 5	8	4		18	10	
	12**	16	26		6	0	
	19	117	108		127	8	
	26	188	14		40	1	
	July, 2	67	20		276	5	
	9	29	4		94	4	
	17	90	14		81	3	
	24	79	17		53	1	
	30	48	0		11	1	
SUN WORLD	May, 28	495	76		46	2	
	June, 5	88	9		20	1	
	12**	3	4		9	1	
	19	49	0		93	5	
	26	39	2		4	1	
	July, 2	80	4		314	12	
	9	23	0		22	2	
	17	8	0		14	0	
	24	95	3		46	3	
	30	52	0		67	0	

* Numbers in table represent totals from 5 samples

** Last date of parasite releases

Table 4. Samples from uncaged potted grape plants infested with VMB and placed under vines for one week* 1998.

Field	Date	Release area Anagyrus	Non release area Anagyrus
Sun World	May, 29	413	75
	June, 5	81	72
	June, 12	35	96
	June, 19	90	58
Organic	May, 29	42	85
	June, 5	53	98
	June, 12	164	62
	June, 19	142	64

***** Numbers in table represent totals from 5 samples

Table 5. Preliminary ant control data: Parasites recovered from caged ant bait trials* 1998

Field	Date		Treatment			
			BAIT		NO-BAIT	
			Anagyrus	Leptomastidea	Anagyrus	Leptomastidea
Sun World	April,	17	0	261	0	927
		24	70	3	40	35
	May,	1	284	104	165	25
		7	168	0	31	48
		15	168	0	378	71
		22	327	50	595	143
Organic	April,	17	0	70	0	393
		24	82	0	41	1
	May,	1	472	1	195	53
		7	37	18	42	7
		15	177	7	155	20
		22	129	34	202	15

* Numbers in table represent totals from 5 samples

Table 6. Comparison of <u>Anagyrus</u> and <u>Leptomastidea</u> from uncaged pots with parasitized VMB versus yellow sticky cards 1998

	Uncaged Pots			Yellow Sticky Cards		
	A	L	VMB	A	L	VMB
4[1]-5[2] June	18	10	-	6	3	76
18[1]-19[2] June	127	8	-	44	2	95
16[1]-17[2] July	81	3	-	524	122	307
30[2]-31[1] July	11	1	-	650	220	70

[1] = Yellow sticky cards (data from J. Ball & K. Godfrey, CDFA)
Totals from 12 samples each week

[2] = Pots with parasitized VMB on potato sprouts
Total from 10 samples each week.

Table 7. Yield from chemically untreated areas with and without parasite releases compared with yield from adjacent vineyards treated twice with lannate to kill VMB

Area	Treatment	Yield (boxes/acre)
Untreated (no chemicals)	None	1220
Untreated (no chemicals)	parasite releases	1220
Commercial	2 applications of Lannate	1082-1201

Figure 1. Mean # of Females Recovered From 7 Trials . A pseudococci. 1996.

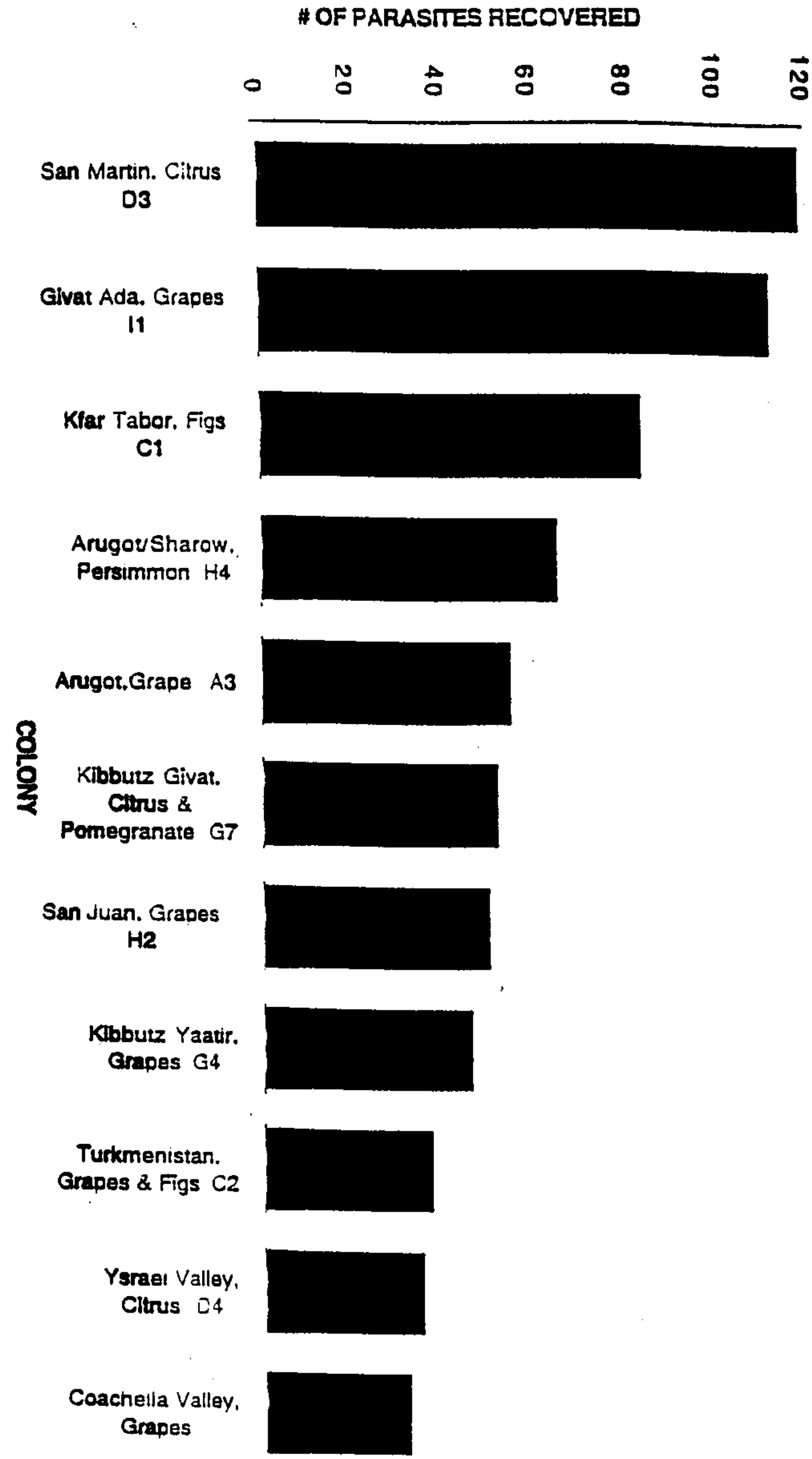


Figure 2

ANAGYRUS PSEUDOCOCCI (except where noted otherwise)

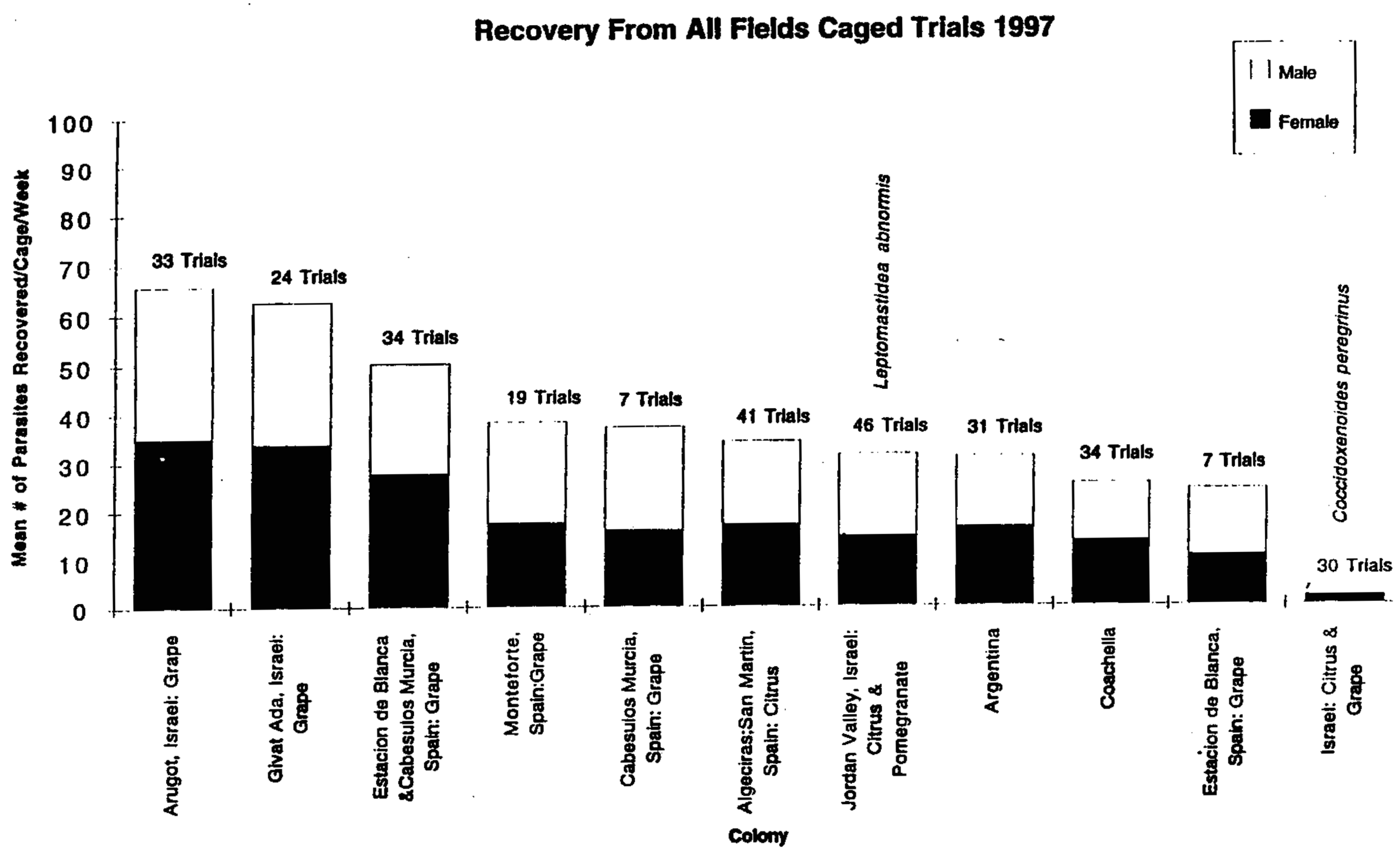


Figure 3

Parasites Recovered in Open Cage Trials 1997

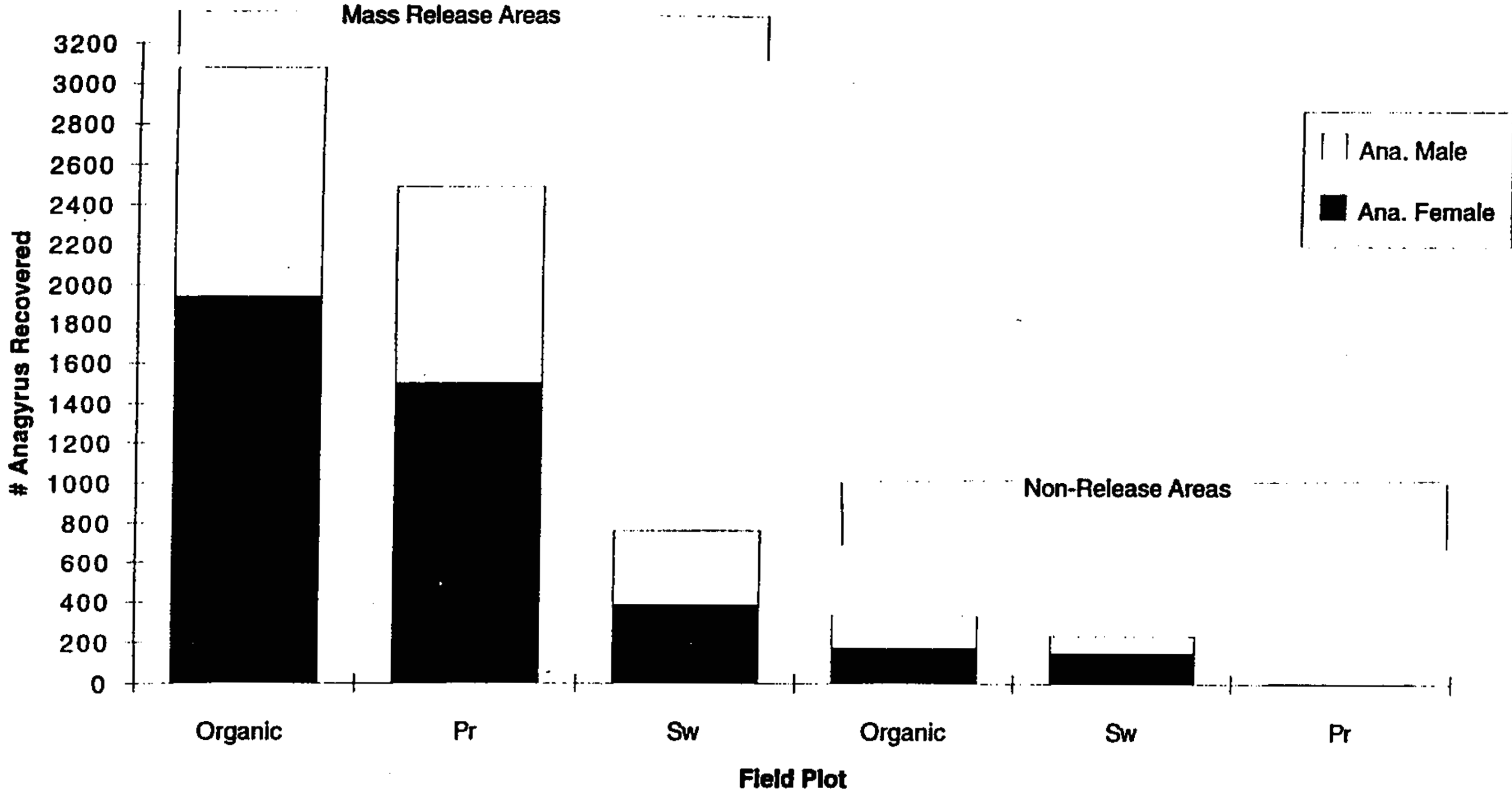
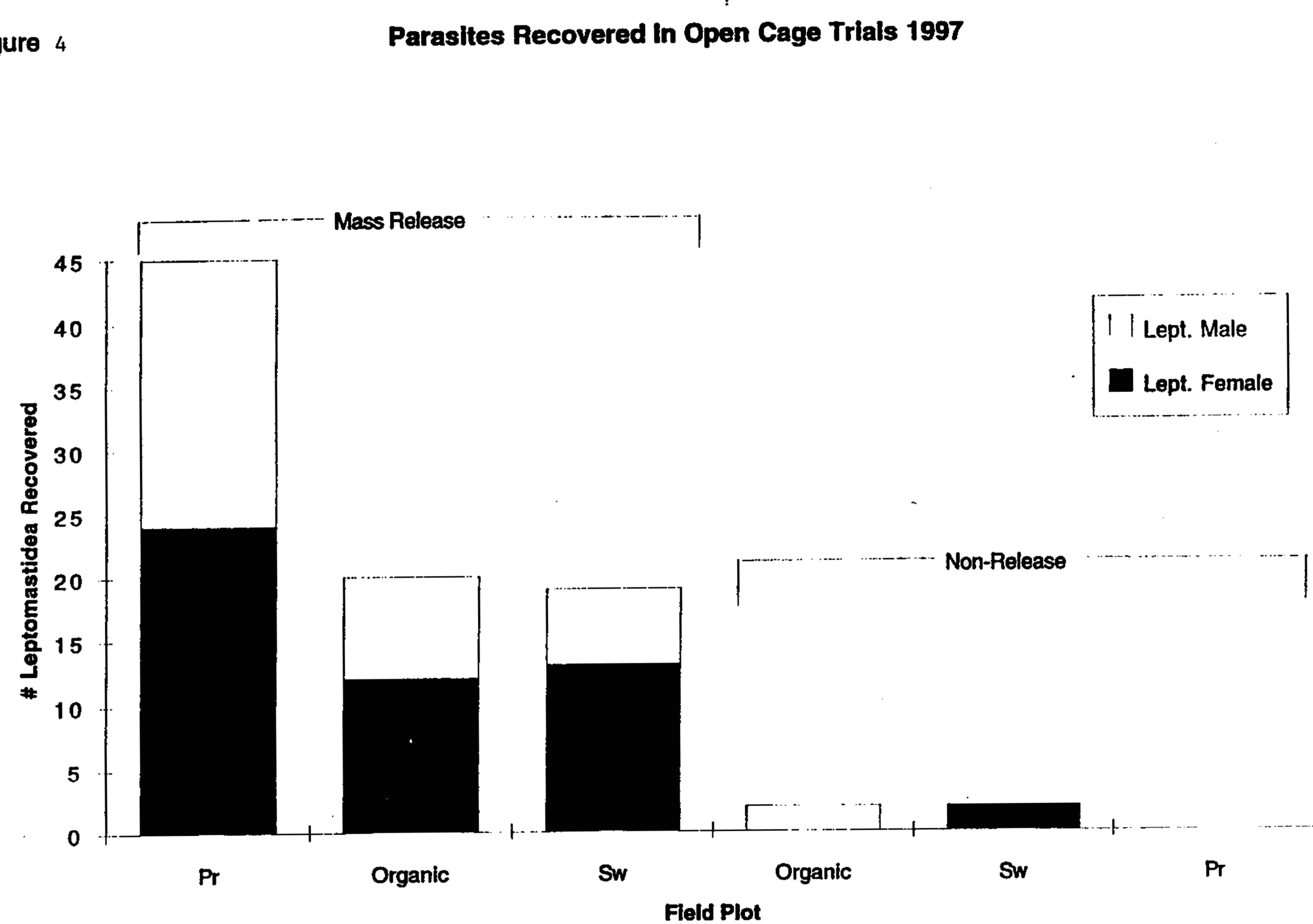


Figure 4



Parasites Recovered In Open Cage Trials 1997
Mass Release
Non-Release
Lept. Male
Lept. Female
Leptomastidea Recovered
45
40
35
30
25
20
15
10
5
0
Pr
Organic
Sw
Organic
Sw
Pr
Field Plot

Figure 5 1998: Pre-release: Early season (Feb.-March) recoveries of parasites from previous years releases

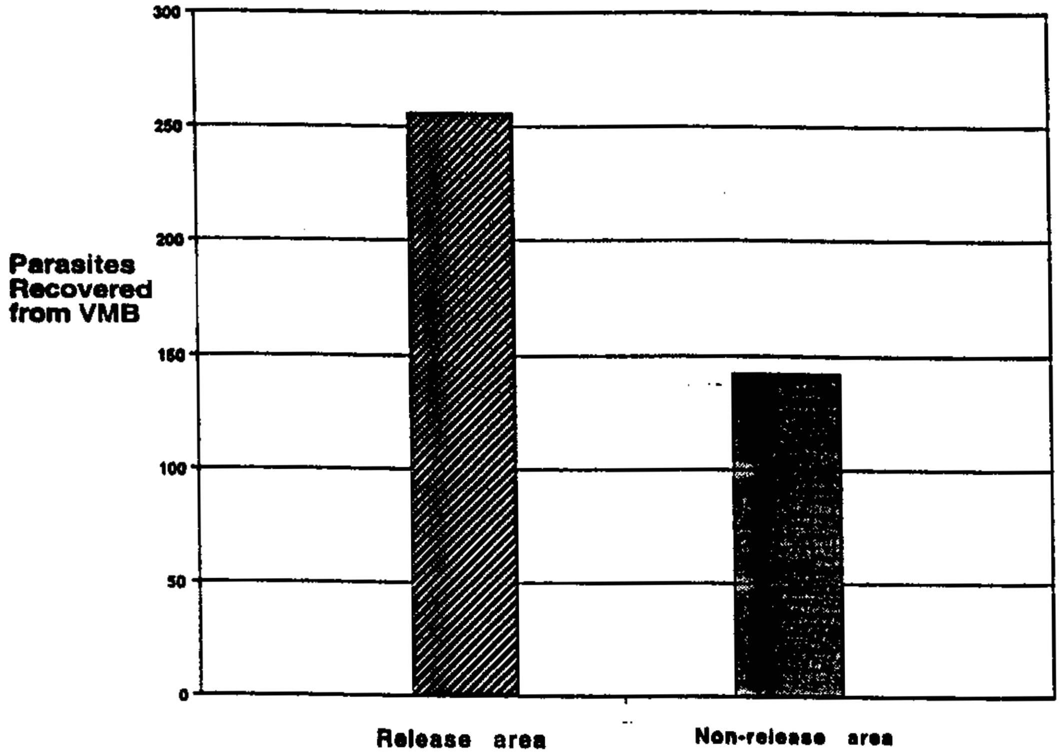


Figure 6 Comparison of Introduced Parasites versus Native Parasites in Parasitizing Vine Mealybug. Organic farm. 1998

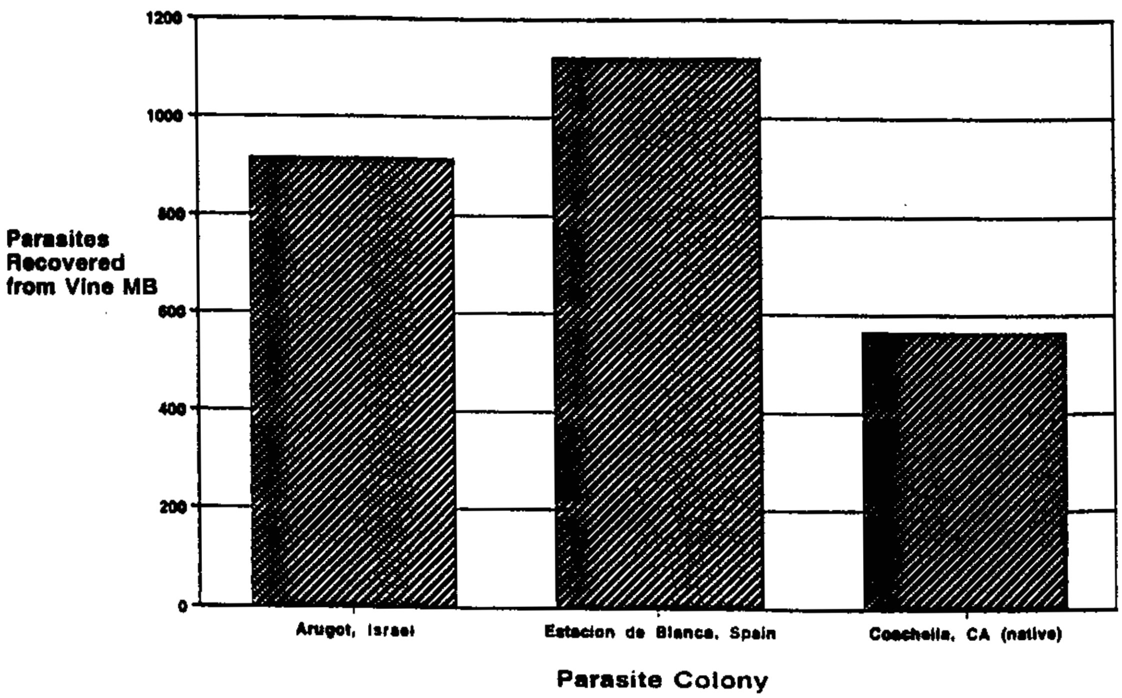


Figure 7. VMB Cage Trials: Comparison of Native vs Introduced Parasites, 1998